M1.(a) Crude oil **OR** petroleum

Not petrol.

1

Fractional distillation / fractionation

Not distillation alone.

1

(b) $C_{12}H_{26} + 12.5O_2 \longrightarrow 12CO + 13H_2O$

Allow balanced equations that produce CO_2 in addition to CO.

Accept multiples.

1

(c) (i) M1 Nitrogen and oxygen (from air) <u>react / combine</u> / allow a correct equation

If nitrogen from petrol / paraffin / impurities CE = 0 / 2.

1

M2 at high temperatures

Allow temperatures above 1000 °C or spark.

Not just heat or hot.

M2 dependent on M1.

But allow 1 mark for nitrogen and oxygen together at high temperatures.

1

(ii) $2NO + O_2 \longrightarrow 2NO_2$

Allow multiples.

1

(iii) $4NO_2 + 2H_2O + O_2 \longrightarrow 4HNO_3$

Allow multiples.

1

(d) (i) C_nH_{2n+2}

Allow C_xH_{2x+2}

CnH2n+2

Allow CxH2x+2

1

(ii) $C_{12}H_{26} \longrightarrow C_6H_{14} + C_6H_{12}$

Only.

1

C_3H_7

Only.

1

Zeolite / aluminosilicate(s)

Ignore aluminium oxide.

1

(iii) Larger molecule / longer carbon chain / more electrons / larger surface area

1

More / stronger <u>van der Waals' forces between molecules</u>

Allow dispersion forces / London forces / temporary induced dipole-dipole forces <u>between molecules.</u>

If breaking bonds, CE = 0 / 2.

1

(e) 2,2,3,3,4,4-hexamethylhexane

Only.

Ignore punctuation.

1

Chain

Ignore branch(ed).

1

(f) Cl_2

Only.

Cl–Cl

Not CL_2 or Cl2 or CL2 or Cl^2 or CL^2.

Ignore Chlorine.

1

[16]

M2.(a) (i) **M1** (Compounds / molecules with) the <u>same structural formula</u>

*Penalise **M1** if 'same structure' or 'different structural / displayed formula'.*

M2 with <u>atoms / bonds / groups</u> arranged <u>differently in space</u>

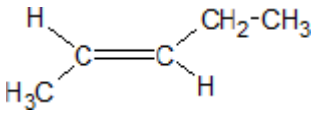
OR <u>atoms / bonds / groups</u> with <u>different spatial arrangements / different orientation</u>

Ignore references to 'same molecular formula' or 'same empirical formula'.

Mark independently.

2

(ii)



Credit C–H_3C

Credit C_2H_5

Penalise C–CH_3CH_2

1

(b) **M1** Br_2 OR bromine (water) OR bromine (in CCl_4 / organic solvent)

*If **M1**, has no reagent or an incorrect reagent, **CE=0**.*

Ignore 'acidified'.

M2 Isomer 1: decolourised / goes colourless / loses its colour

*For **M1** penalise Br (or incorrect formula of other correct reagent), but mark on.*

M3 Isomer 2: remains orange / red / yellow / brown / the same **OR** no reaction

/ no (observable) change **OR** reference to colour going to the cyclopentane layer

*For **M1**, it must be a whole reagent and / or correct formula.*

*If oxidation state given in name, it must be correct. If 'manganate' OR 'manganate(IV)' or incorrect formula, penalise **M1**, but mark on.*

Alternatives : potassium manganate(VII)

M1 $KMnO_4$ in acid **M2** colourless **M3** purple

M1 $KMnO_4$ in alkali / neutral **M2** brown solid **M3** purple

Credit for the use of **iodine**

M1 iodine (solution / in KI) **M2** colourless **M3** (brown) to purple (credit no change)

Credit for the use of **concentrated H_2SO_4**

M1 concentrated H_2SO_4 **M2** brown **M3** no change / colourless

Ignore 'goes clear'.

Ignore 'nothing (happens)'.

Ignore 'no observation'.

No credit for combustion observations.

3

(c) (i) (Both infrared spectra show an absorption in range) **1620 to 1680** (cm^{-1})

Ignore reference to other ranges (eg for C–H or C–C).

1

(ii) The fingerprint (region) / below 1500 cm^{-1} will be different **or** its fingerprinting will be different

OR

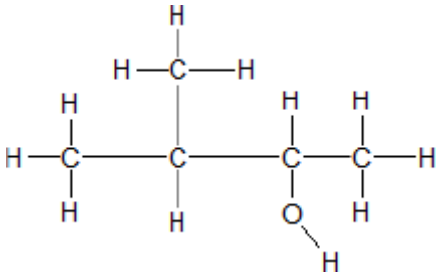
different absorptions / peaks are seen (in the region) below 1500 cm^{-1} (or a specified region within the fingerprint range)

*Allow the words 'dip' **OR** 'spike' **OR** 'low transmittance' as alternatives for absorption.*

QoL

1

(d)



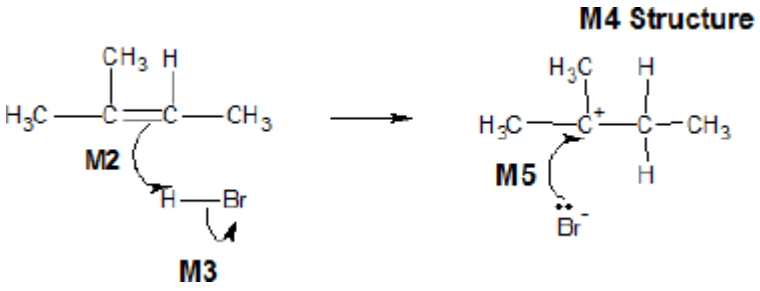
All bonds must be drawn.

Ignore bond angles.

1

(e) (i) **M1 Electrophilic addition**

***M1** both words needed.*



Penalise one mark from <u>their</u> total if half-headed arrows are used.

M2 must show an arrow from the double bond towards the H atom of the H–Br molecule

***M2** Ignore partial negative charge on the double bond.*

M3 must show the breaking of the H–Br bond

***M3** Penalise incorrect partial charges on H–Br bond and penalise formal charges.*

M4 is for the structure of the tertiary carbocation

*Penalise **M4** if there is a bond drawn to the positive charge.*

Penalise once only in any part of the mechanism for a line and two dots to show a bond.

M5 must show an arrow from the lone pair of electrons on the negatively charged bromide ion towards the positively charged carbon atom of either a secondary or a tertiary carbocation

*For **M5**, credit attack on a partially positively charged carbocation structure but penalise **M4**.*

***<u>Max 3 of any 4 marks in the mechanism</u>** for wrong organic reactant or wrong organic product (if shown) or secondary carbocation.*

***<u>Max 2 of any 4 marks in the mechanism</u>** for use of bromine.*

Do not penalise the correct use of 'sticks".

NB The arrows here are double-headed

5

(ii) **M1** Reaction goes via intermediate carbocations / carbonium ions

***M1** is a lower demand mark for knowledge that carbocations are involved.*

M2 (scores both marks and depends on M1)

Tertiary carbocation / carbonium ion is more stable (than the secondary carbocation / carbonium ion)

OR

Secondary carbocation / carbonium ion is less stable (than the tertiary carbocation / carbonium ion)

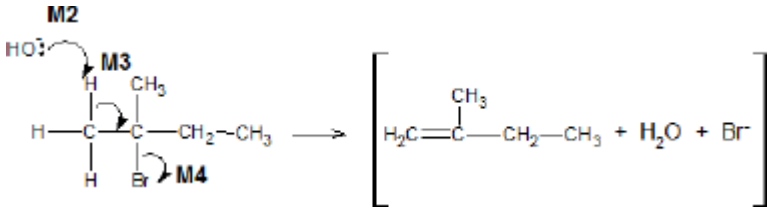
***M2** is of higher demand and requires the idea that the secondary carbocation is less stable or the tertiary carbocation is more stable. Reference to incorrect chemistry is penalised.*

A carbocation may be defined in terms of alkyl groups / number of carbon atoms, rather than formally stated.

2

(f) **M1 Elimination**

***M1** credit 'base elimination' but no other qualifying prefix.*



Penalise one mark from their total if half-headed arrows are used.

M2 must show an arrow from the lone pair on oxygen of a negatively charged hydroxide ion to a correct H atom

*Penalise **M2** if covalent KOH*

M3 must show an arrow from a correct C–H bond adjacent to the C–Br bond to a correct C–C bond. Only award if an arrow is shown attacking the H atom of a correct adjacent C–H bond (in **M2**)

M4 is independent provided it is from their original molecule **BUT penalise M2, M3 and M4 if nucleophilic substitution** shown

Award full marks for an E1 mechanism in which **M2** is on the correct carbocation

NB The arrows here are double-headed

*Penalise **M4** for formal charge on C or Br of the C–Br bond or incorrect partial charges on C–Br.*

*Penalise **M4** if an additional arrow is drawn from the Br of the C–Br bond to, for example, K^+.*

Ignore other partial charges.

*Penalise **once only** in any part of the mechanism for a line and two dots to show a bond.*

***Max 2 of any 3 marks in the mechanism** for wrong reactant or wrong organic product (if shown) or a correct mechanism that leads to the alkene 2-methylbut-2-ene.*

Credit the correct use of "sticks" for the molecule except for the C–H being attacked.

M5 hydroxide ion behaves as a base / proton acceptor / electron pair donor / lone pair donor

*Penalise **M5** if 'nucleophile'.*

5

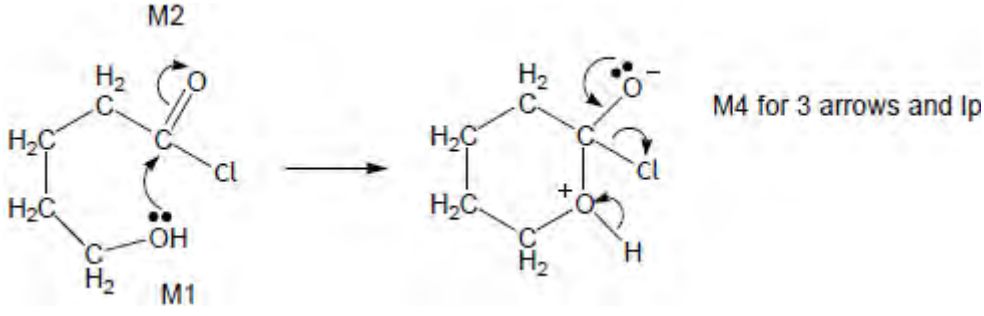
[21]

M3.(a) (i) (nucleophilic) addition-elimination

Not electrophilic addition-elimination

Ignore esterification

1



M3 for structure

- *If wrong nucleophile used or O–H broken in first step, can only score M2.*
- *M2 not allowed independent of M1, but allow M1 for correct attack on C+*
- *+ rather than δ+ on C=O loses M2.*
- *If Cl lost with C=O breaking lose M2.*
- *M3 for correct structure with charges but lone pair on O is part of M4.*
- *Only allow M4 after correct / very close M3.*
- *Ignore HCl shown as a product.*

4

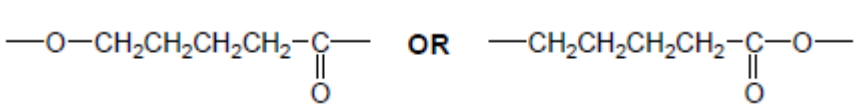
a 20-50 (ppm) or single value or range entirely within this range

If values not specified as a or b then assume first is a.

1

b 50-90 (ppm) or single value or range entirely within this range

1

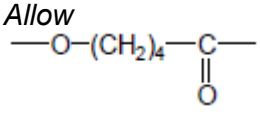
(ii)  **OR**

Must have trailing bonds, but ignore n.

1

OR –$OCH_2CH_2CH_2CH_2CO$– **OR** –$CH_2CH_2CH_2CH_2COO$–

Allow



but not - C_4H_{8-}

one unit only

Condensation

1

(b)

	Tollens'	*Fehling's / Benedicts*	*Acidified potassium dichromate*
J	*No reaction / no (visible) change / no silver mirror*	*No reaction / no (visible) change / stays blue / no red ppt*	*No reaction / no (visible) change / stays orange / does not turn*

Penalise wrong formula for Tollens or missing acid with potassium dichromate but mark on.

1

			green

Ignore 'clear', 'nothing'.
Penalise wrong starting colour for dichromate.

1

K	*Silver <u>mirror</u> / grey <u>ppt</u>*	*Red <u>ppt</u>* *(allow brick red or red-orange)*	*(orange) turns green*

1

J *Two (peaks)*
Allow trough, peak, spike.

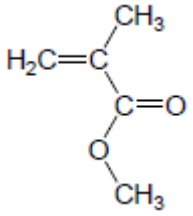
1

K *Four (peaks)*
Ignore details of splitting.
If values not specified as J or K then assume first is J.

1

(c) If all the structures are unlabelled, assume that the first drawn ester is L, the second ester is M; the first drawn acid is N, the second P. The cyclic compound should be obvious.

L
ester

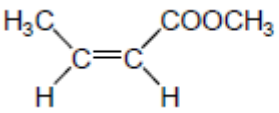


OR $H_2C=C(CH_3)COOCH_3$
All $C_5H_8O_2$ L to P must have C=C.
Allow CH_3–.
Allow $-CO_2CH_3$ etc.
Allow $CH_2C(CH_3)COOCH_3$.

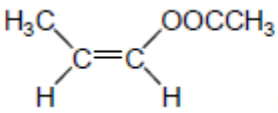
1

M

ester



OR



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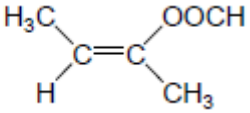
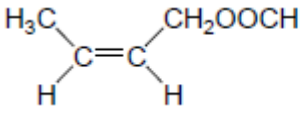
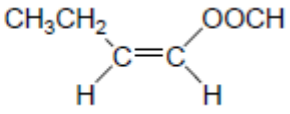


$CH_3CH=CHCOOCH_3$ *$CH_3CH=CHOOCCH_3$* *$CH_3CH=C(CH_3)OOCH$*



OR



OR

$CH_3CH=CHCH_2OOCH$ *$CH_3CH_2CH=CHOOCH$*

Allow either E–Z isomer.

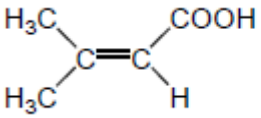
Allow CH_3– or C_2H_5– but not CH_2CH_3–.

Allow $CH_3CHCHCOOCH_3$ etc.

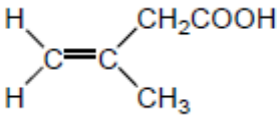
1

N

acid



OR



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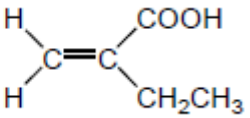


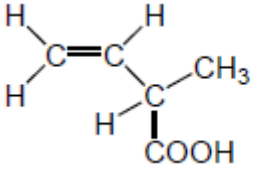
$(CH_3)_2C=CHCOOH$ *$H_2C=C(CH_3)CH_2COOH$* *$H_2C=C(COOH)CH_2CH_3$*

Allow CH_3– or C_2H_5– but not CH_2CH_3–.

Allow −CO_2H.

Not cyclic isomers.

Not the optically active isomer.



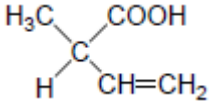
which is P anyway

Allow $(CH_3)_2CCHCOOH$ etc.

1

P

acid



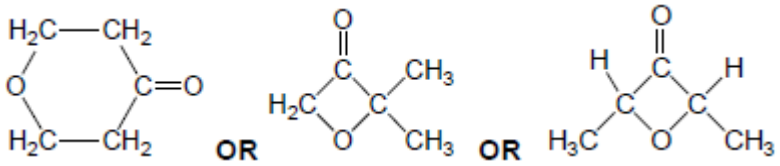
Allow −CO_2H.

$CH_3CH(COOH)CH=CH_2$

Allow $CH_3CH(CO_2H)CHCH_2$ *or* $CH_3CH(CO_2H)C_2H_3$.

1

Q



Not cyclic esters.

1

[19]